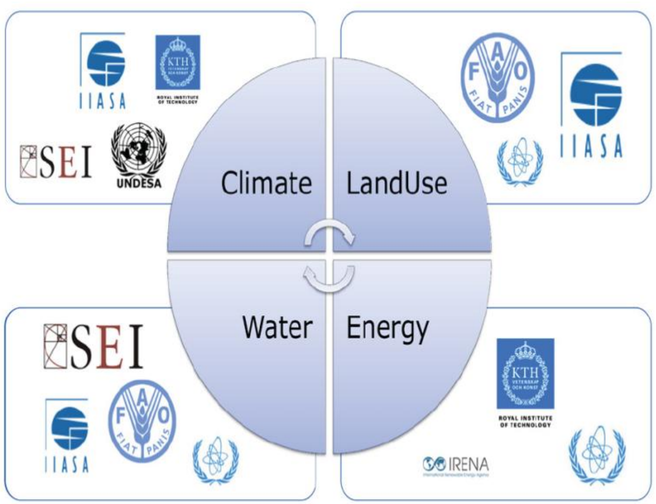
Seeking Security and Sustainability CLEWs Climate Land Energy and Water Strategies

Mark Howells**, *Sebastian HermanRebecka Segerström, Manuel Welsch*

***Prof. and Director: division of Energy Systems Analysis*

Royal Institute of Technology, Sweden



Credit and notes:

- *Credit to Collaborators: SEI, FAO, UNDESA, IAEA, JISR, IIASA, IRENAConsidering the energy, water and food nexus: Towards an integrated modeling approach (Original research article) Energy Policy, Volume 39, Issue 12, December 2011, Pages 7896-7906 Morgan Bazilian, Holger Rogner, Mark Howells, Sebastian Hermann, Douglas Arent, Dolf Gielen, Pasquale Steduto, Alexander Mueller, Paul Komor, Richard S.J. Tol, Kandeh K. Yumkella*
- *Adding Value with CLEWS – Modelling the Energy System and its Interdependencies for Mauritius (working paper) Welsch M., Hermann S., Howells M., Rogner H.H., Young C., Ramma I., Bazilian M., Fischer G., Alfstad T., Gielen D., Le Blanc D., Röhrl A., Steduto P., Müller A.*
- *Climate, land, energy and water (CLEW) inter linkages in Burkina Faso: An analysis of agricultural intensification and bio-energy production Natural resources Forum (accepted October 2012) Sebastian Hermann, Manuel Welsch, Rebecka Ericsdotter Segerstrom, Mark I. Howells, Charles Young, Thomas Alfstad, Hans-Holger Rogner, and Pasquale Steduto*
- *Integrated Energy-Water System Modeling ; Methodological options for modeling with the MESSAGE software and pilot study on the South African system (Working paper series) Kinga Csontos, Thomas Alfstad, and Mark Howells*

Division of Energy Systems Analysis: Overview

Research areas:

1. *Strategic security*
2. *The Human prospect: Access to services*
3. *Multi-resource modeling*
4. *Economic transition*
5. *Sustainability dialogues*

Model databases:

- *World*
- *Africa*
- *Sweden, Isreal, Cyprus, NZ etc.*

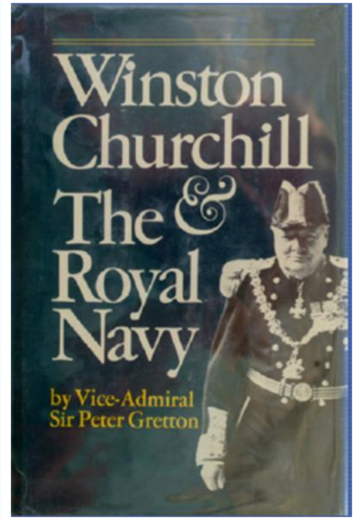
Toolkits

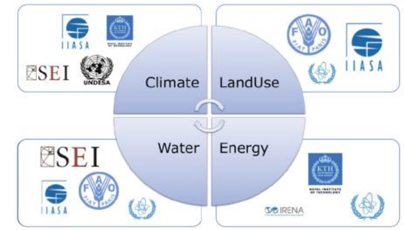
- *OSeMOSYS*
- *CLEW*

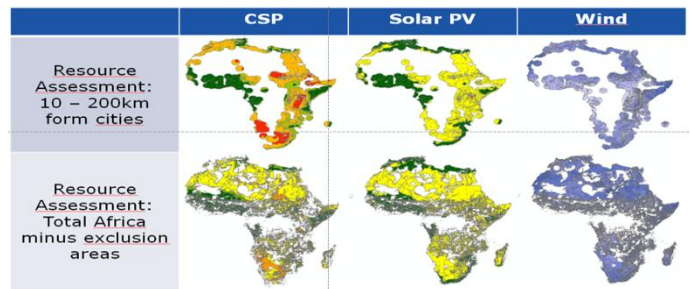
External relationships:

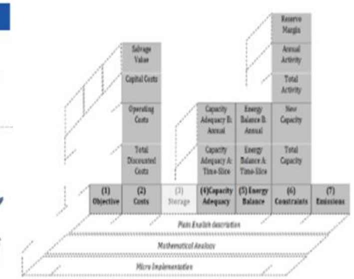
- *IRENA*
- *IAEA*
- *UNDESA*
- *JISR*
- *Others*

RIO+20
United Nations Conference
on Sustainable Development





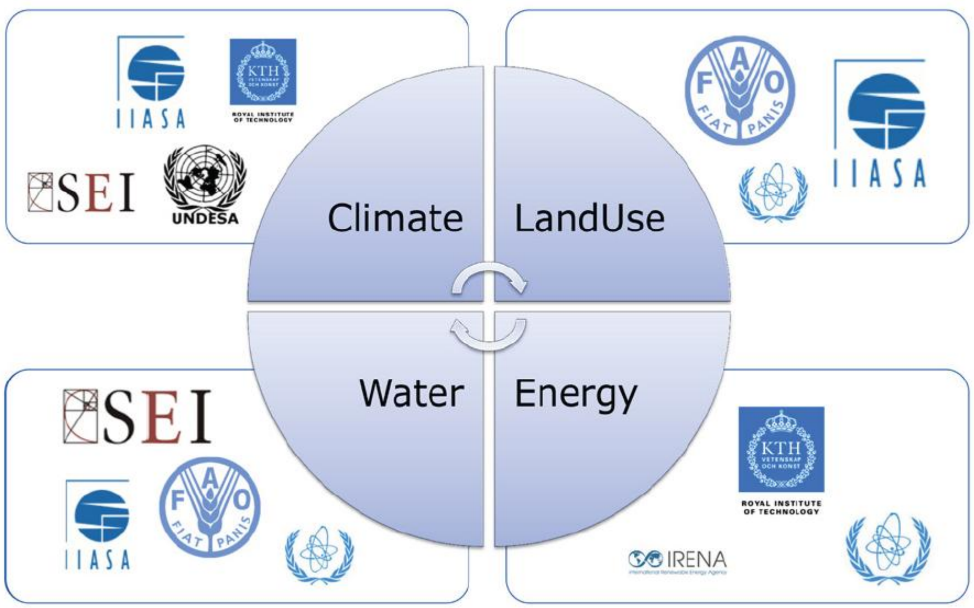


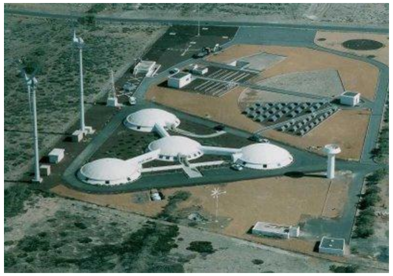


CLEWS

We need to find sustainable development CLEWS: Climate, Land, Energy and Water strategies. This is an acronym given to a set of methodologies that are being developed at a number of leading institutions (including KTH). Some specific goals are to find out:

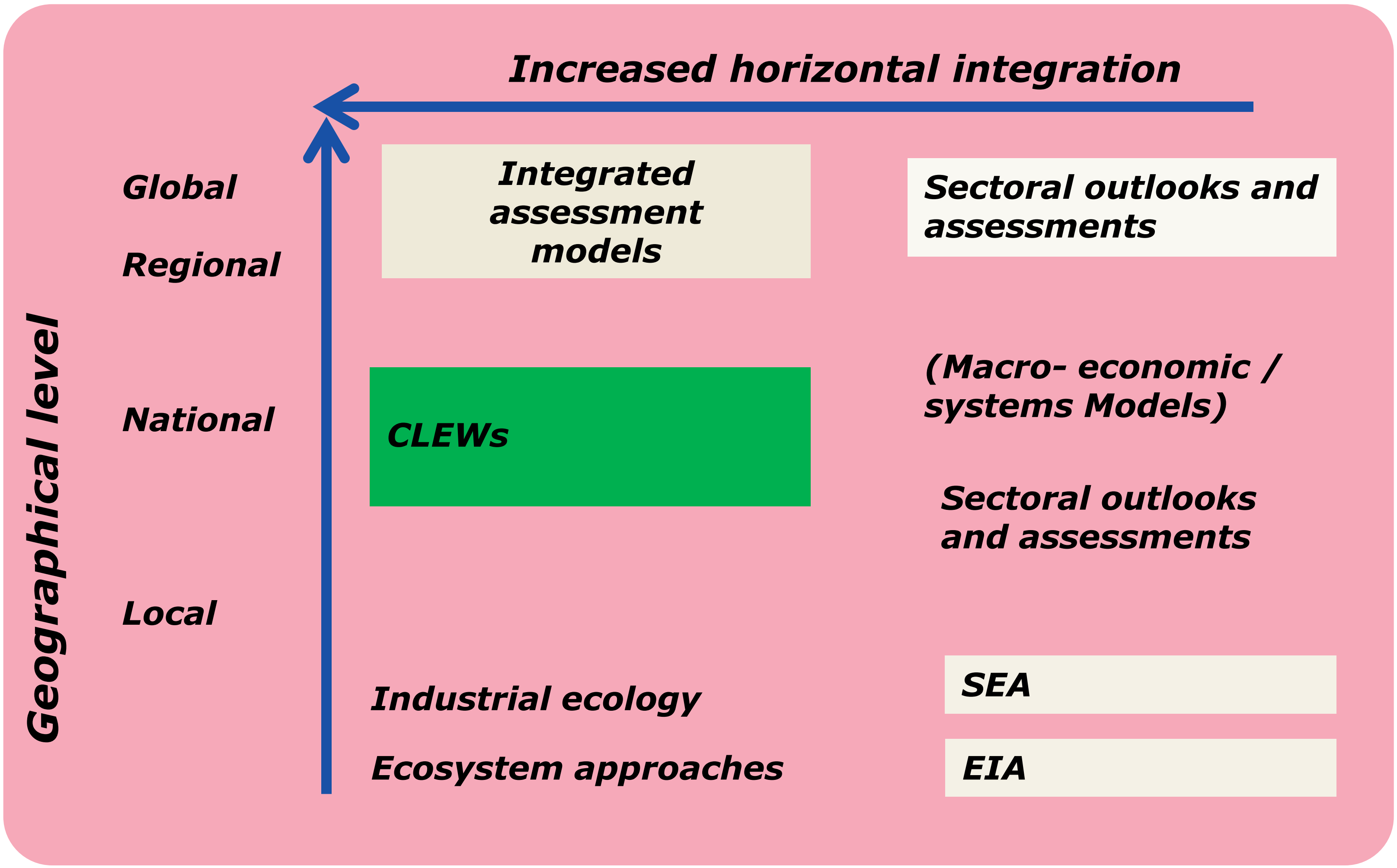
- How we can meet these common development needs in a sustainable manner
- What technologies and configurations of technologies are best going to help
- What policies are going to make this feasible and economically viable – and thereby help reduce future conflicts
- And what happens if we do nothing…





ROYAL INSTITUTE OF TECHNOLOGY

CLEWs evolution – the application space



(shade of green: degree of Increased economic – biophysical integration)

Le Blanc 2011. Bonn Nexus Conference

Model evolution. Energy +

Input

- Exogenous water and energy demand
- Technology specification
  - Water efficiency
  - Energy efficiency
- **Output**
- Cost optimal allocation of energy and water use technologies
- **South Africa, NYC** (at BNL by now staff)

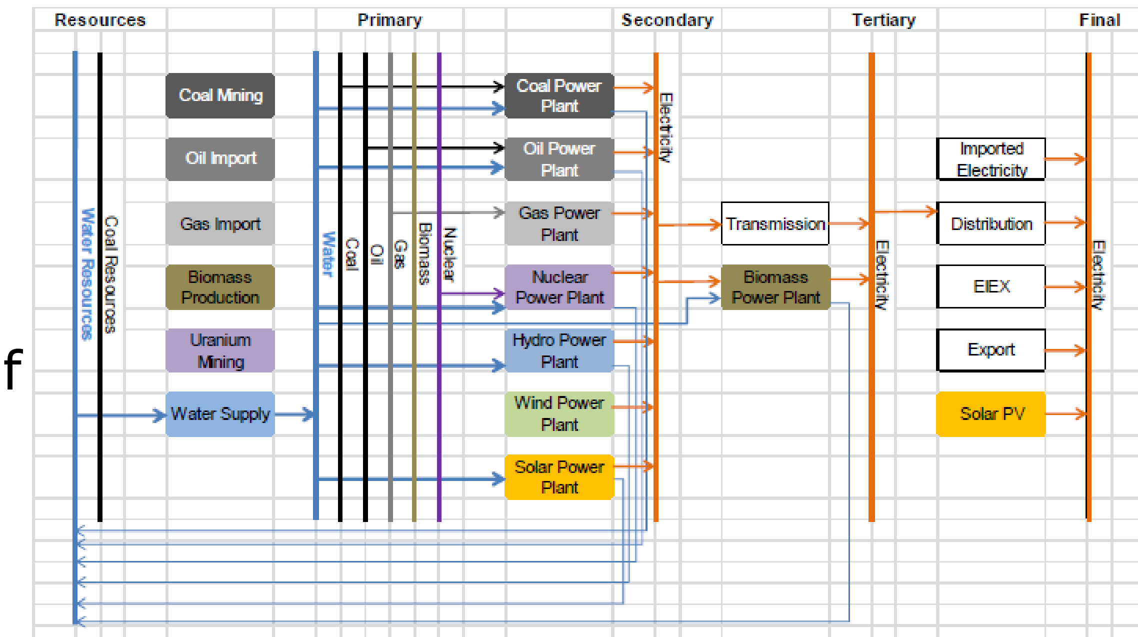


Figure 4: Reference Energy-Water System (REWS) based on the South-African electricity supply system

Model type 1. Full integration

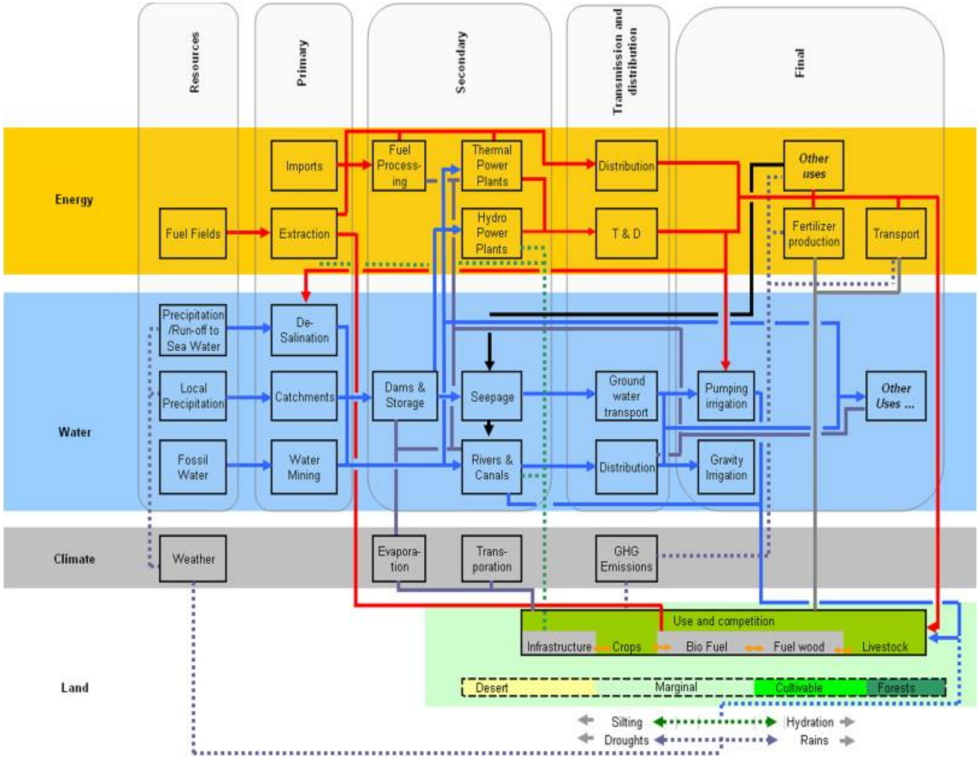
Input

- Land limits and yields
- Water balance
- Technology specification
- Exogenous demands
- Project orientated

Output

- Crop
- Water
- Energy
- CO2 balance

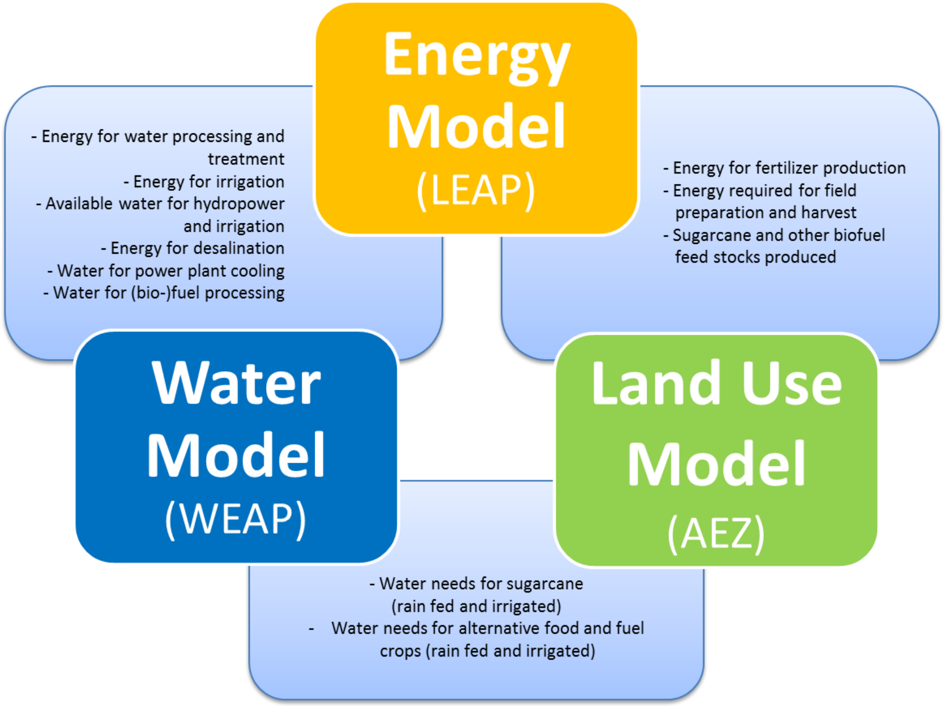
Jamaica, Mauritius, Pacific



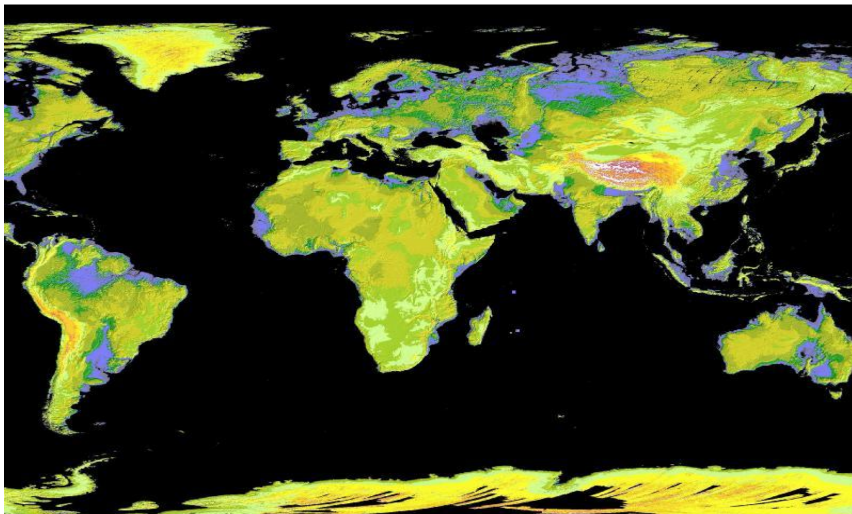
Model type 2. All soft-linked

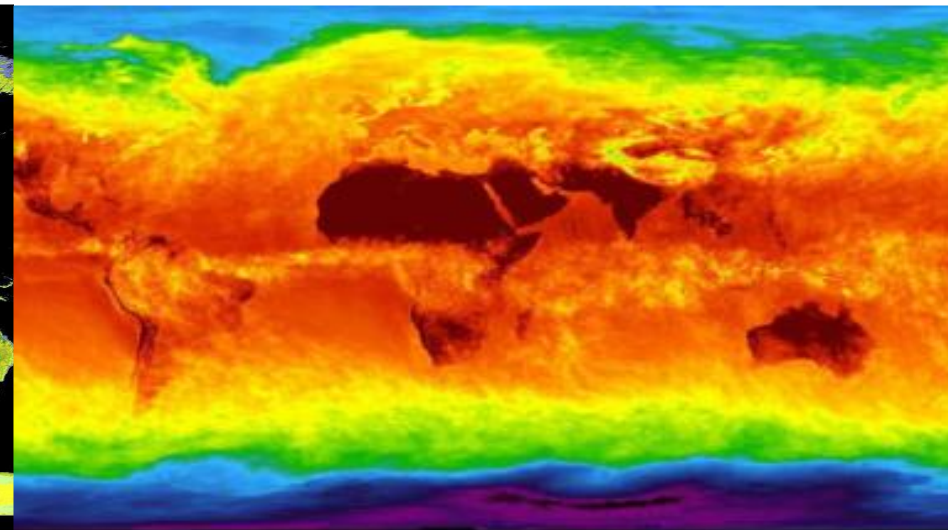
Input

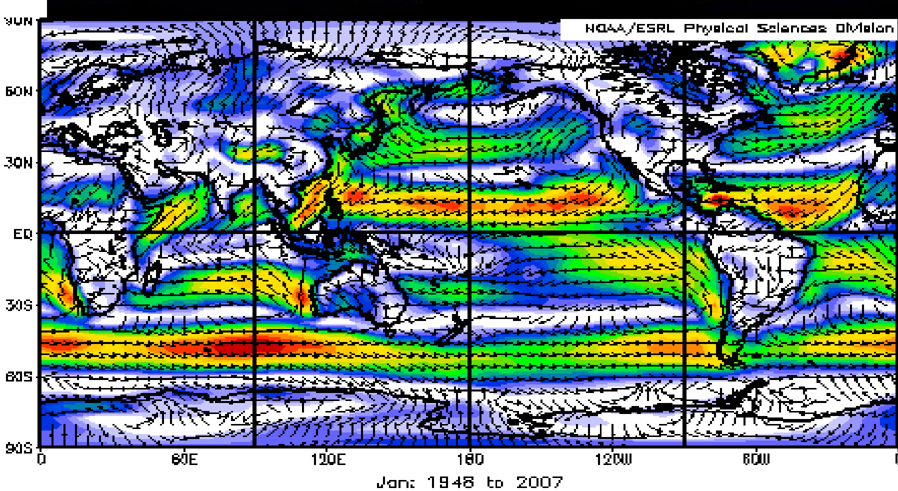
- Exogenous water, food and energy demand
- Technology specification
  - Water efficiency
  - Energy efficiency
- Agro-ecological zoning
- Future weather expectations
- Basin info
- **Output**
- Consisent scenairos
- Water, energy, food balance
- **Mauritius, Burkina Faso**

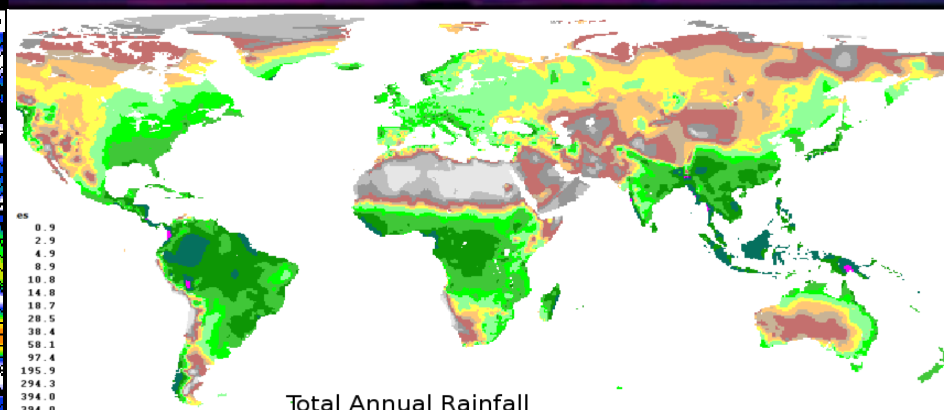


And NASA data is used for each …

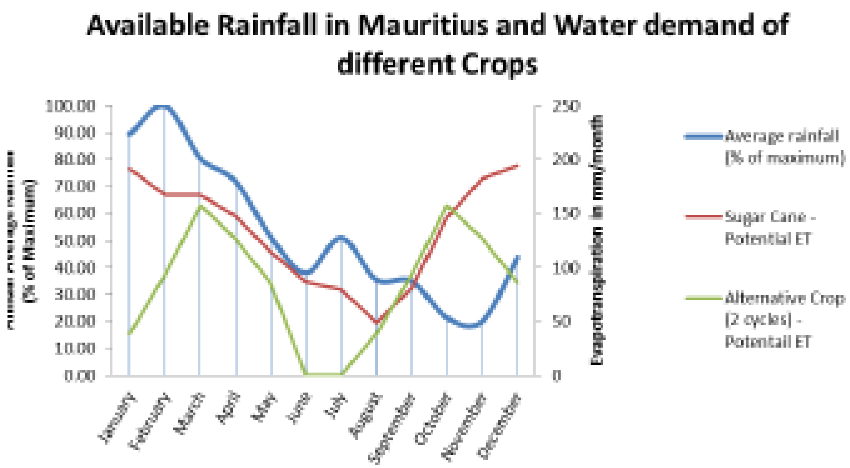




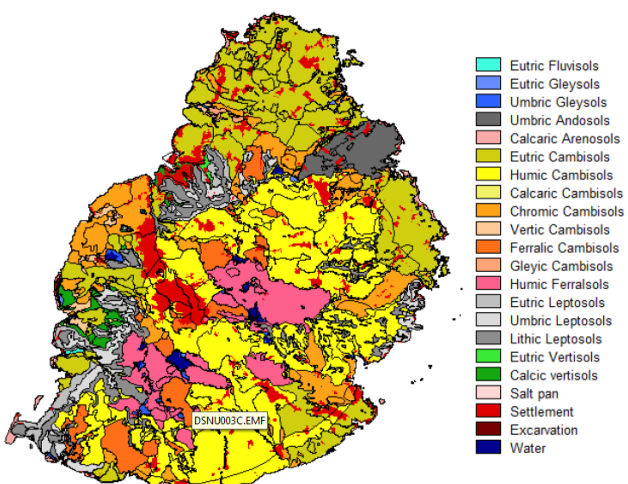




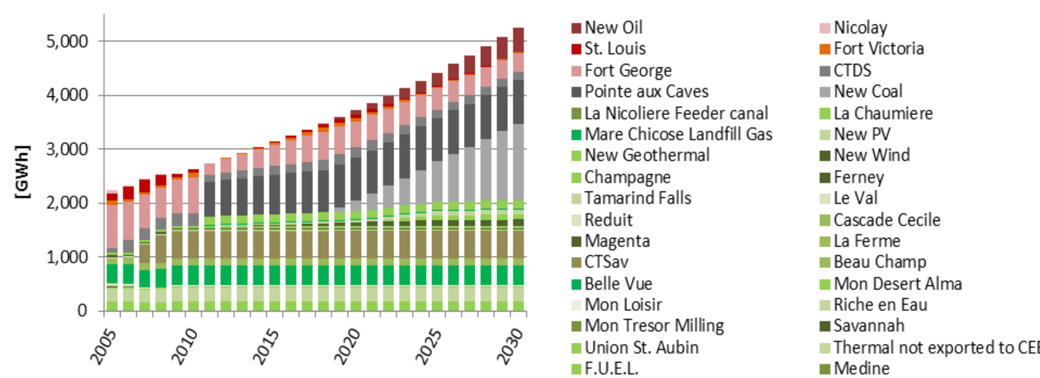
Case Study 1: Mauritius



Basin level water modellig

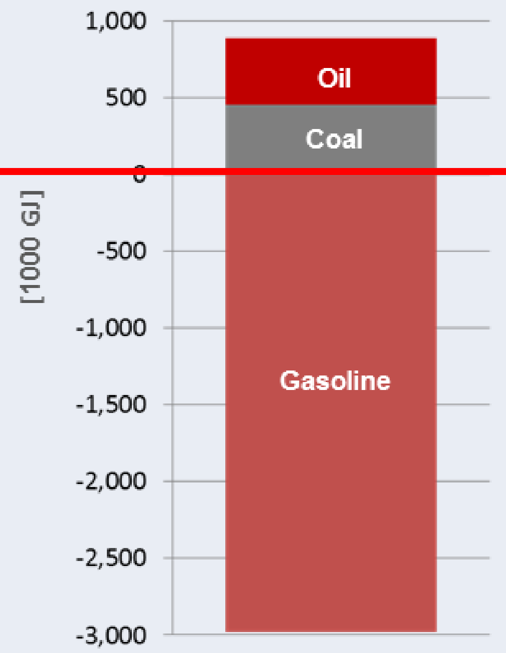
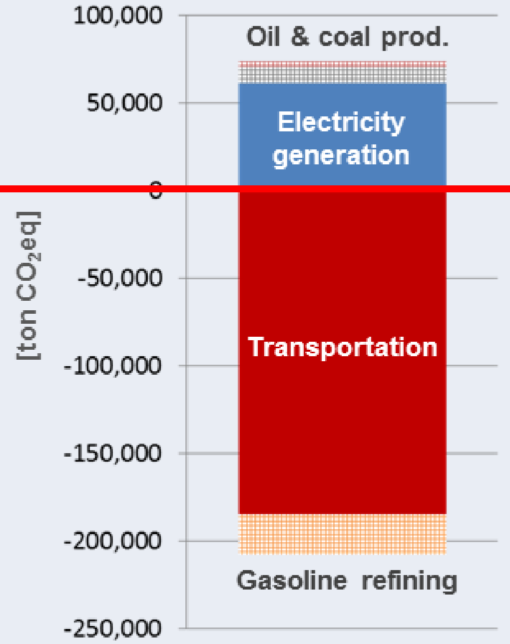
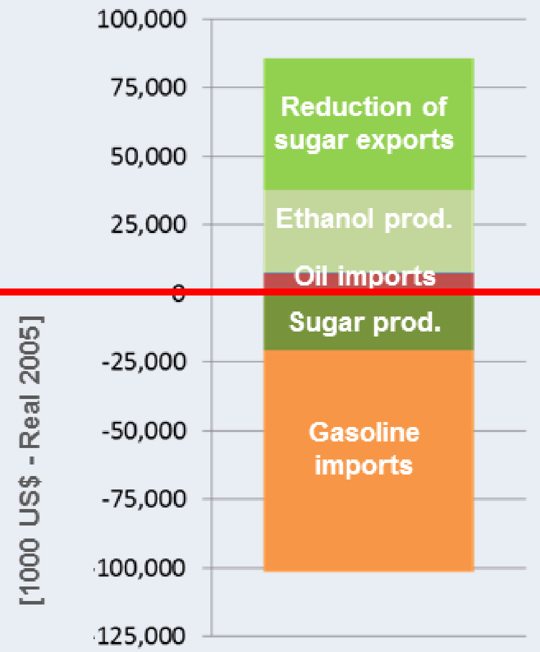


Soil Map of Mauritius (FAO'90 dominant soils)



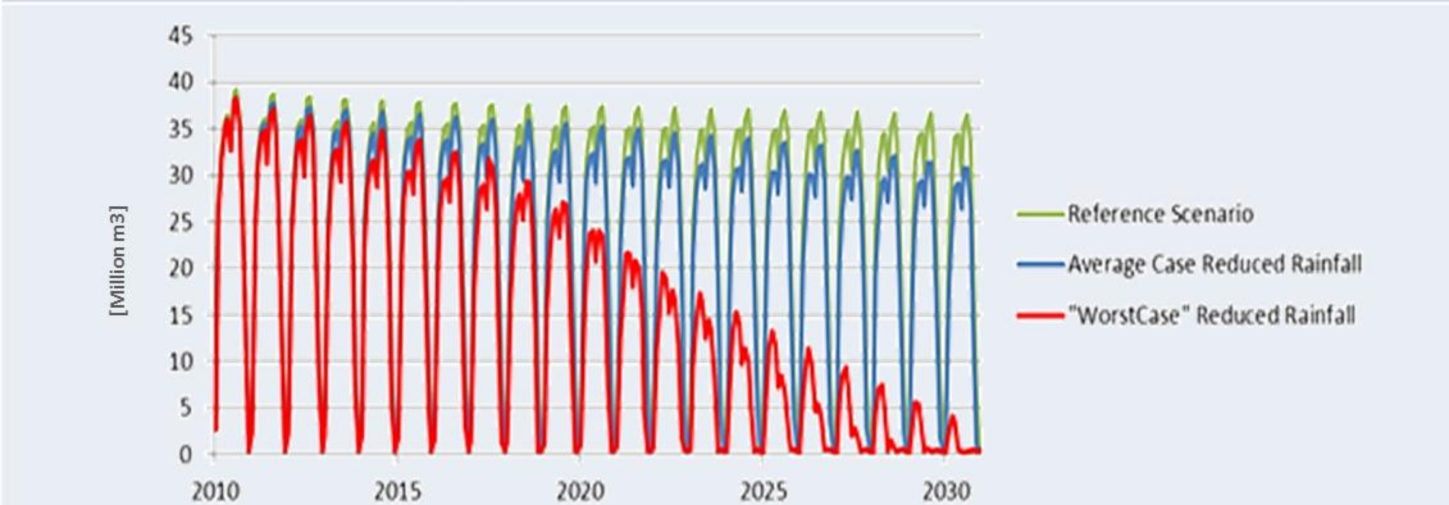
Electricity modelling

Case Study 1: Mauritius
Switching from sugar to biofuel

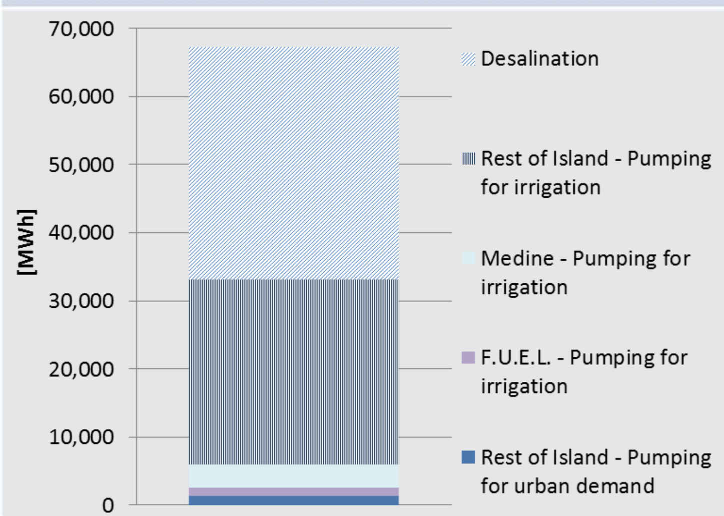
Reduced fuel imports	Reduced greenhouse gas emissions	Reduced expenditures
		

Case Study 1: Mauritius
Integrating **C***LEWS* **Climate**

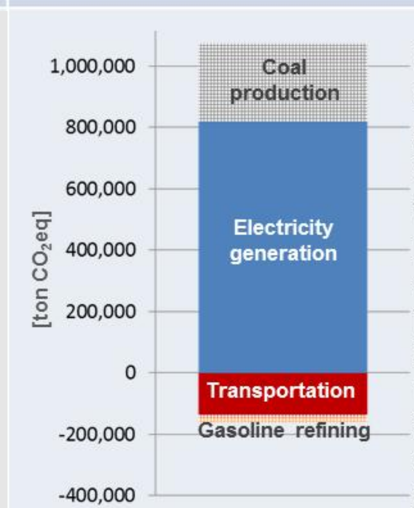
Storage volume level of reservoirs in Mauritius



Additional energy demand for water in 2030



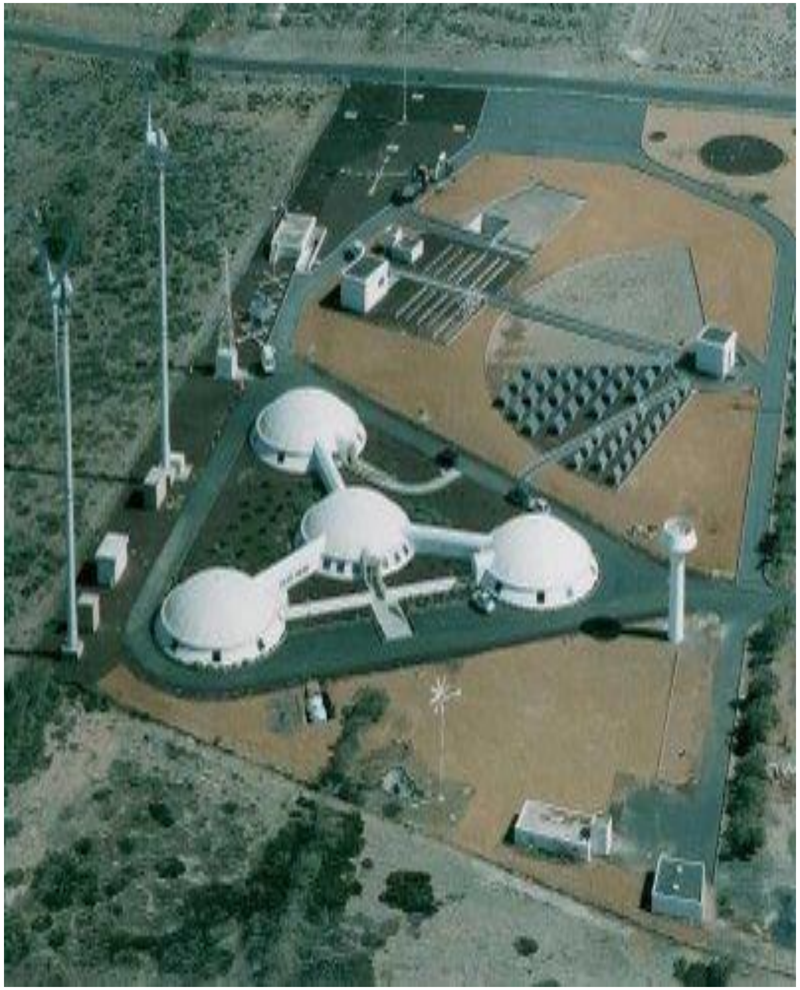
Additional greenhouse gas emissions in 2030



Due to this additional energy demand, overall greenhouse gas emissions increase.

The additional demand is largely met by coal-based electricity generation. These emissions cannot be compensated by the reductions in the transport sector due to 1st generation ethanol production.

Case Study 1: Mauritius
Oportunities …!!



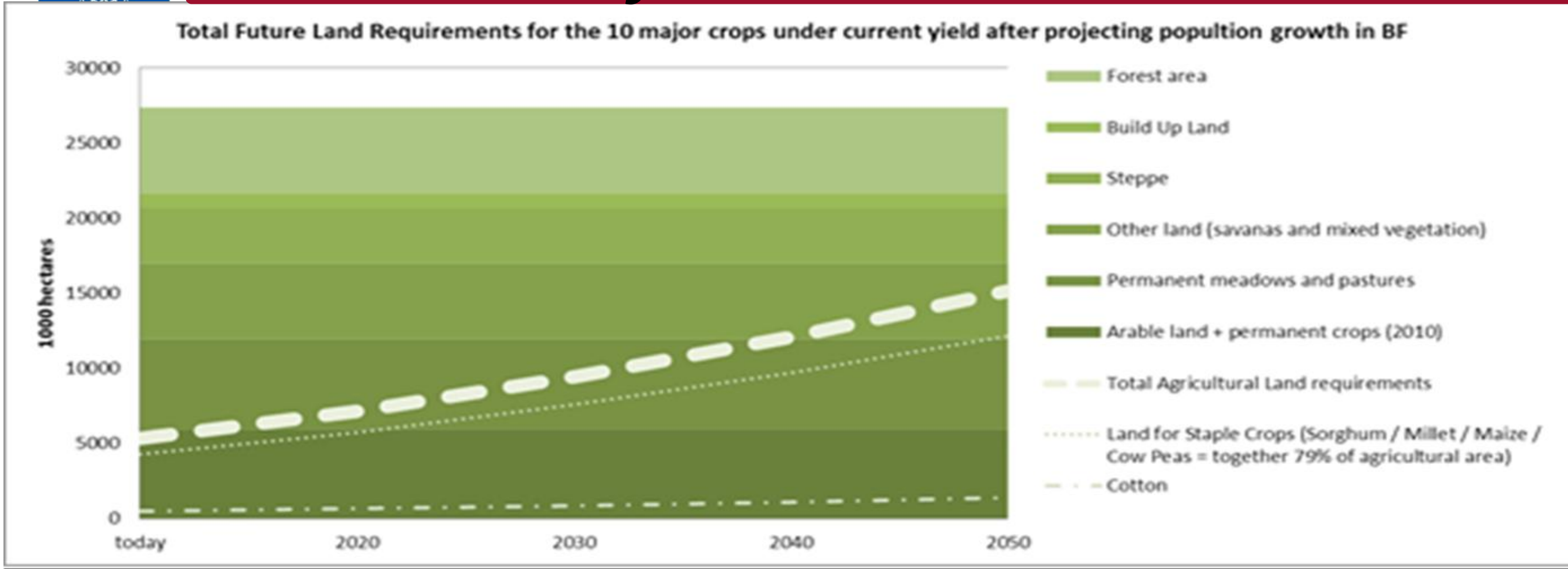
What the engineers see:

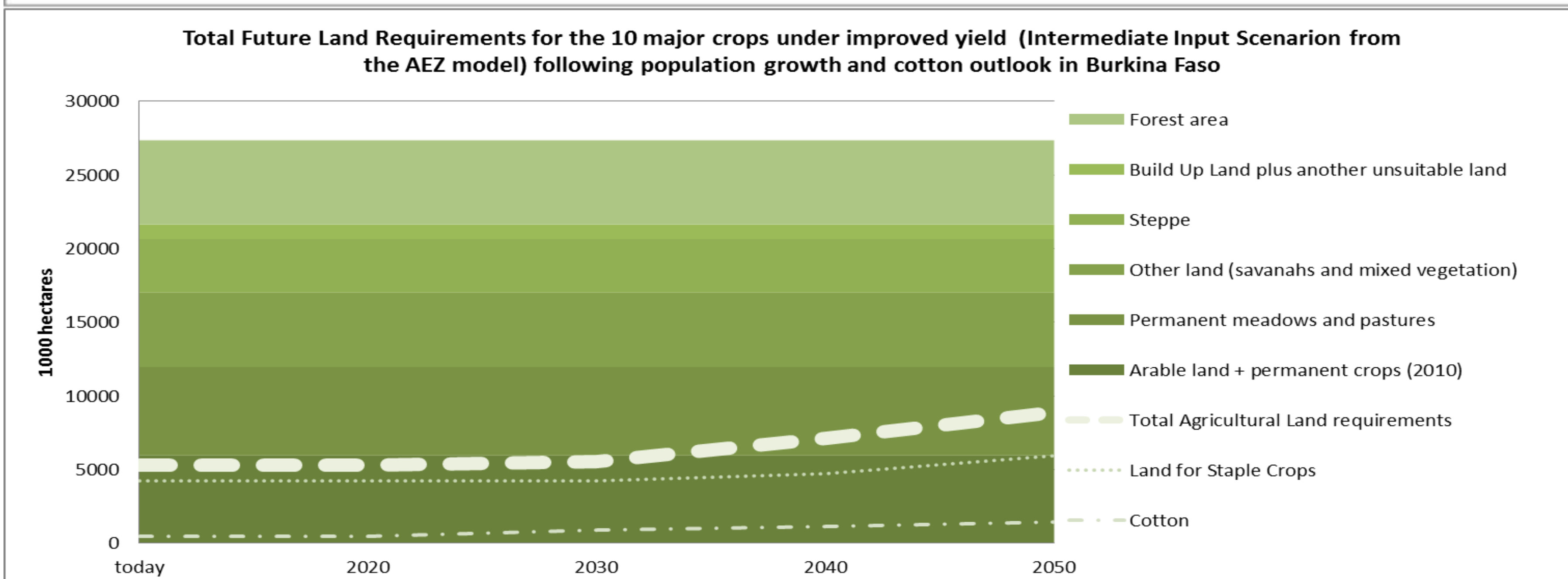
1. *Electricity is expensive to store*
2. *The penetration of intermittant renewables is limited*
3. *So stick with coal*
4. *Electricity planners see a growing fixed demand (inc. Desal)*
5. *Water planners see desal water as expensive putting agriculture at risk*
6. *Limited scope to reduce demand*

But:

- *Storing water is cheap (compared to electricity)*
- *You consider desalinating water as a load that can easily be shifted*
- *Further, there is potential for smart water pumping (another variable load)*
- *Allows for large penetrations of RE*
- *Ups water, food and energy security*

Case Study 2: Burkia Faso

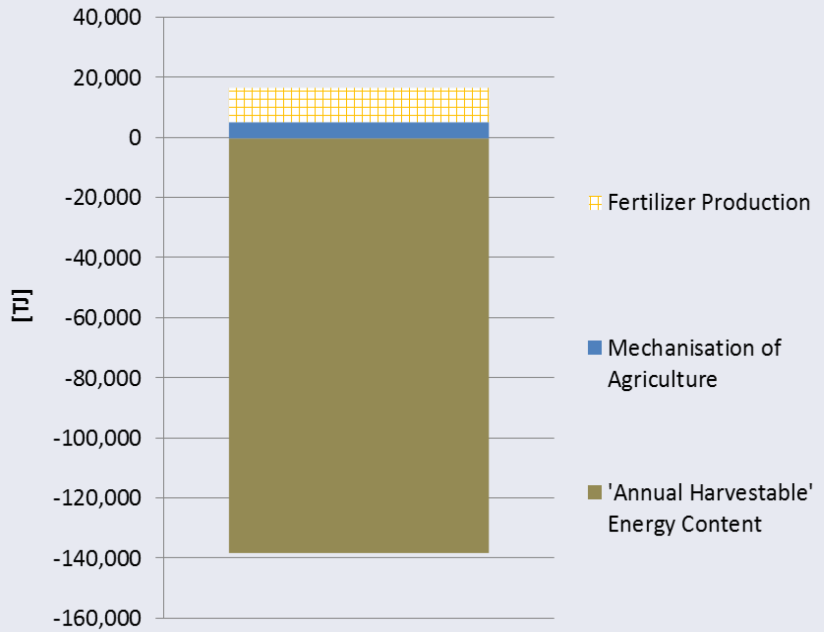




Case Study 2: Burkia Faso

Figure 1: Effects of Intensification of Agriculture Compared to Business-as-Usual

Changes in the Energy Balance in 2020



Reduced energy balance due to reduced land-use change

An intensification of agriculture associated with 'intermediate input levels' would require an increased energy input for mechanisation and as well for the production of fertilizer.

This increase is small compared to the biomass energy that could be sustainably harvested from the land that would otherwise have been converted to crop land

The fuel wood energy potential is calculated based on harvestable yields available land-types (e.g., forest, savannah, meadows) not displaced to the expansion of cropland.

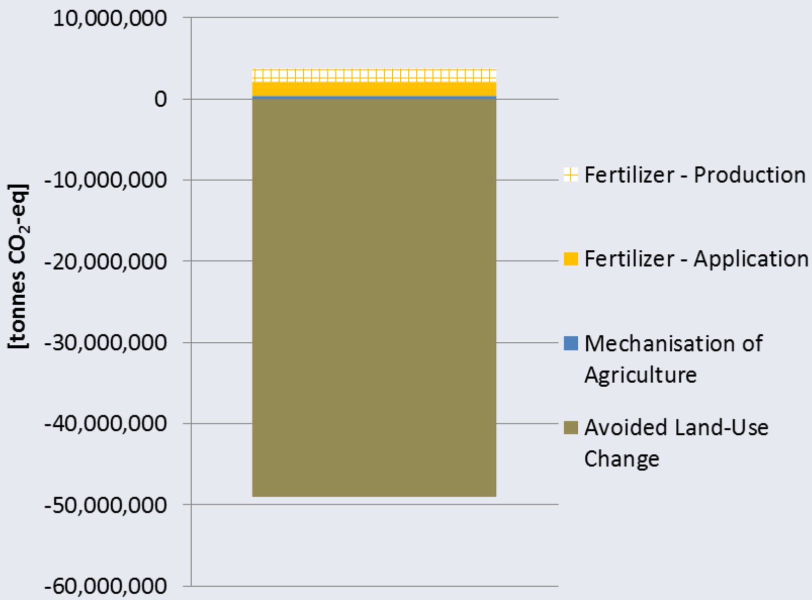
Key Assumptions

- An additional energy input for mechanisation of 1 GJ/ha
- An additional fertilizer input of 50 kg N/ha
- A fuel wood yield in savanna and mixed vegetation of 35 m^3/ha and 250 m^3/ha in forests

Case Study 2: Burkia Faso

Figure 2: Effects of Intensification of Agriculture Compared to Business-as-Usual

Changes in Greenhouse Gas Emissions in 2020



Significant greenhouse gas reductions

An intensification of agriculture associated with 'intermediate input levels' would as well significantly reduce the overall greenhouse gas balance compared with the business-as-usual case.

The largest increase in emissions is associated with the production of fertilizer.

This increase is outweighed by the reductions in emissions due to the reduced need to convert meadows, savannah and forests into agricultural land.

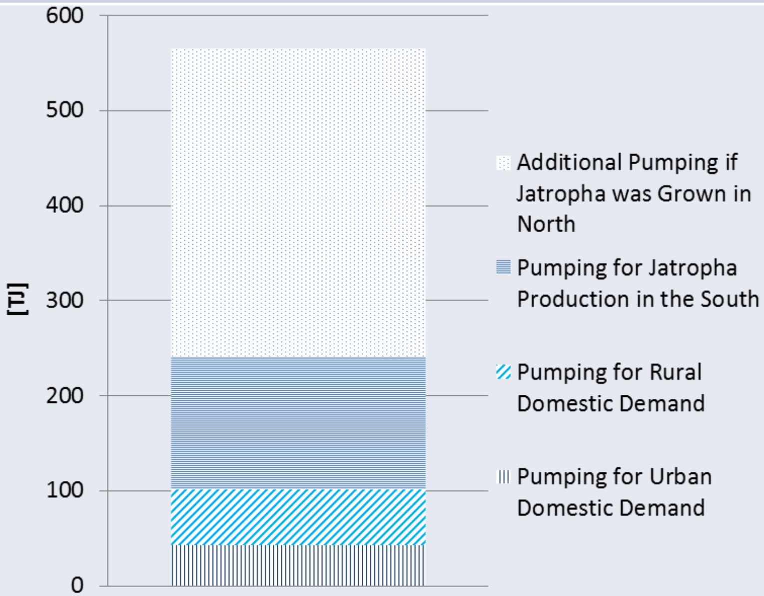
Key Assumptions

- An additional energy input for mechanisation of 1 GJ/ha, all from diesel
- An additional fertilizer input of 50 kg N/ha with natural gas as its main energy input
- Average greenhouse gas emissions of 135 tons of CO_2/ha for converting savanna and meadows into crop land and 600 tons of CO_2/ha for converting forests

Case Study 2: Burkia Faso

Figure 3: Biofuel Production and its Share in Total Energy Requirements for Pumping

Energy Requirements for Pumping in 2020



Energy requirements for irrigation are much lower if Jatropha is grown in the South.

If Jatropha for biofuel production is grown in the South on 1% of the agricultural land, the related energy requirements for pumping of 140 TJ would amount to 4% of the current electricity demand of 950 GWh (=3,420 TJ). The yearly biofuel output would be 1,630 TJ.

More than three times of the energy for pumping (equalling 460 TJ in total) would be required to grow Jatropha in the North. While the required irrigation levels in the North would deplete groundwater resources, it would also significantly deteriorate the energy balance of biofuel production.

In 2020, meeting both urban and rural water demand requires a similar amount of energy. This will change in the future, when urban demand will dominate.

Key Assumptions

- 300 mm of irrigation required to grow Jatropha in the South, 1,000 mm to grow it in the North
- A pumping efficiency of 50% and an average pumping depth of 50m
- 50% of the urban and 70% of the rural population rely on groundwater

ROYAL INSTITUTE OF TECHNOLOGY

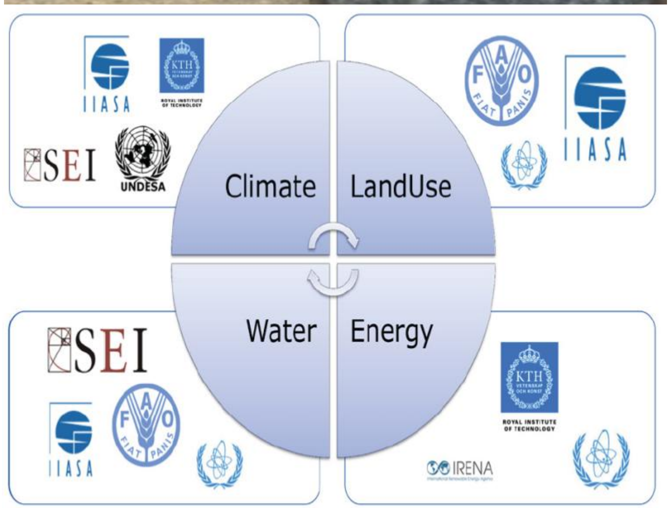
Is this having an impact …?

http://webtv.un.org/search/mauritius-general-debate-3rd-plenary-meeting-rio20/1700992573001?term=Rio%2020

4 min 35 sec…

10 new country case studies:
India, Australia, US, Cuba and others ….

Some concluding thoughts …



- Large scope for improving integrated solutions
- Give the potential resource crunches and climate vulnerabilities such an approach is needed to look at facility security
- Allows one to consider ’embodied’ resources throughout …
- Development of a CLEWs model with GIS-OSeMOSYS
- A global CLEWs model is starting with UNDESA
- Very initial steps to develop a city level model
- Without NASA data none of this would be possible without much much more effort –THANK YOU!